International Journal of Mechanical and Production
Engineering Research and Development (IJMPERD)
ISSN(P): 2249–6890; ISSN(E): 2249–8001
Vol. 9, Issue 6, Dec 2019, 171–182

EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE CHARACTERISTICS OF A DIESEL ENGINE FUELLED WITH LINSEED OIL METHYL ESTER BLENDS WITH TiO_2 NANOFLUID AS A COOLANT

A. JASWANTH[1], G. S. GURU DATTATREYA[2] & B. VEERABHADRA REDDY[3]

[1]*PG Scholar, Department of Mechanical Engineering, G. Pulla Reddy Engineering College (Autonomous), Kurnool, Andhra Pradesh, India*

[2]*Assistant Professor, Department of Mechanical Engineering, G. Pulla Reddy Engineering College (Autonomous), Kurnool, Andhra Pradesh, India*

[3]*Professor, Department of Mechanical Engineering, G. Pulla Reddy Engineering College (Autonomous), Kurnool, Andhra Pradesh, India*

ABSTRACT

At present, prices of oil are increasing day-by-day and due to greenhouse effect, the methyl ester fuels were exploited as alternative fuels. The purpose of the present work is the conversion of raw linseed oil into corresponding methyl ester through transesterification procedure. For a diesel engine, adequate coolant is needed for enhancing the engine efficiency. Furthermore, in this study, TiO_2 (Titanium Oxide) nano-fluid is used as a coolant to remove an excess amount of heat from the engine and improves engine efficiency. The purpose of the present exploration is to evaluate performance characteristics of linseed oil and methyl ester of linseed oil blends with TiO_2 nanofluid as a coolant at different loads. A single cylinder, diesel engine with DC generator has been chosen for the exploration. Engine tests have been carried out to acquire comparison of brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency and volumetric efficiency and then contrasted with diesel. Experimental evaluation showed that the methyl ester of linseed oil blends with TiO_2 nano-fluid as a coolant gives better performance compared to linseed oil blends.

KEYWORDS: Diesel Engine, Transesterification, TiO_2 Nano-Fluid, Linseed Oil & Performance Characteristics

Received: Aug 02, 2019; **Accepted:** Aug 22, 2019; **Published:** Oct 14, 2019; **Paper Id.:** IJMPERDDEC201915

Original Article

1. INTRODUCTION

Transesterification is a widely used method, which uses methanol in presence of a catalyst like sodium hydroxide or potassium hydroxide in order to breakdown the particle of the oil into an ester and glycerol [1]. Biodiesel is exploited as a powerful elective fuel. It is imitative from plant oil and fats. The serious issue of exploited vegetable oil in diesel engine is its thickness. Thus it requires Transesterification process, where triglyceride responds with liquor in the event of impetus to acquire biodiesel [2]. Generally, biodiesel is bio-degradable, non-poisonous, and produces fewer emissions. Biodiesel is the best option among various sources as a result it has the capacity to diminished the emissions [3]. The innovative creation of thermal exchange fluids called nano-fluids. Generally, the thermal exchange in motor cooling device is improved by exploiting nano-fluid as a coolant [4]. As of late, many researchers were utilized nanofluids in automobiles for several applications, for example, coolant, fuel additive and refrigerant [5]. The deduction of heat transfer from the vehicle engine cooling system is done by exploiting nanofluid as a coolant [6]. The performance and emissions characteristics of a diesel engine fuelled with two biodiesels, Type 'A' and Type 'B' are basically investigated and the

utilization of fuel for biodiesel 'B' is greater than Biodiesel 'A' [7]. The thermal efficiency of the engine is decreased and the specific fuel consumption is increased with the utilization of jatropha oil [8]. Jinmao chen and Jianguang jia [9] explored that heat transfer performance of TiO_2 nanofluid is drastically increased when contrasted with base coolant without nano-particles. T. Balamurugan et al., [10] determined the performance and emission attributes of a diesel engine using the mixes of corn oil and observed that decrement in brake thermal efficiency, increment in BSES for all blends in contrast to diesel. Savita dixit et al., [11] explored the linseed oil generation, composition and its properties. The fundamental goal of this exploration is to give a report on the linseed plant, biodiesel generation from the linseed oil. V. Dhana raju and P. Ravindra kumar [12] arranged various mixes of neem oil and linseed oil methyl esters with proportions of (B05, B10, B15, B20) were utilized to run on a CI engine and assessed emission and performance attributes of a engine and observed that the blend LSOME-B20 is taken as an optimum blend. J. Hemanandh and K. V. Narayanan [13] assessed the performance and emission attributes of an engine by utilizing hydrotreated sunflower oil mixes of HTSF25, HTSF100 at distinct load conditions and noticed that the thermal efficiency is increased by 10 and 38%, BSFC by 25 and 12.5% respectively. Sukumar puhan et al., [14] conducted an experiment on compression ignition engine exploiting methyl ester of linseed oil mixes with diesel fuels with various fuel injection pressures of 200, 220 and 240 bar and assessed the performance and emission attributes of a diesel engine and observed that at 240 bar injection pressure, thermal efficiency is like diesel and lessening in emissions of CO and HC. S. Bhanu Teja [15] in this paper, the accumulation of methanol to LSME utilizing carburettor changing throttle openings and the fuel utilization, performance and emission attributes are studied and noticed that fuel consumption and brake thermal efficiency increases with increase in percentage of methanol. P. Srinivasa rao et al., [16] evaluated the performance characteristics of a diesel engine utilizing linseed oil blends (L10, L20, L30) with diesel fuels were used to run on a diesel engine and observed that the increment in brake thermal efficiency by 7.21% in contrast to diesel. Increase in BSFC by 4.56% in contrast to diesel. Rajeev kumar et al., [17] explored that the non edible oils properties, generation of biodiesel and then contrasted with that of diesel and revealed that the biodiesel imitative from the non edible vegetable oils could be the best choice of elective fuel. Bhupendra singh chauhan et al., [18] conducted an experiment on dual engine utilizing the blends of jatropha oil and evaluated performance and emission characteristics and observed that increment in BSFC and decrement in brake thermal efficiency in contrast to diesel. K. Vijayaraj and A. P. Sathiyagnanam [19] conducted a test on kirloskar diesel engine utilizing the mixes of mango seed oil methyl ester with various extents and assessed the performance attributes of a diesel engine. From the test reports, revealed that the BTE of B25 is nearer to diesel and increment in BSFC with the accumulation of biodiesel. Ahmet Uyumaz [20] explored that indicated thermal efficiency decreases, BSFC increases with the utilization of mustard oil blends and observed that M10 is taken as an optimum blend. K. Nantha Gopal et al., [21] revealed that pongamia biodiesel has less lewdness because of the formation of deposit, and observed that the viscosity of PME20 blend is very less. Nadir yilmaz [22] evaluated the performance characteristics of a diesel engine with the consumption of alcohol and biodiesel and then contrasted with that of diesel. Experimental results showed that the alcohol concentration is decreased in biodiesel and alcohol blends has identical impacts to preheating the intake air temperature. Ankur Nalgundwar et al., [23] in this research work, various sorts of jatropha and palm oil blends were tried to run on a diesel engine with distinct loads. Experimental results demonstrated that for the lower blend D90PB5JB5 indicated 4.65% increment in brake thermal efficiency in contrast to diesel fuel and BSFC is decreased for lower blends. J. Sadhik Basha and R. B. Anand [24] revealed that the brake thermal efficiency is greater for carbon nano tubes (CNT) mixed jatropha methyl ester emulsion contrasted with that of jatropha methyl ester emulsion and jatropha methyl ester. A. Sanjit et al., [25] in this research paper, performance and emissions of palm and jatropha biodiesel mixes are explored in contrast to diesel. From test results, it is observed that increment in BSFC for all mixes when contrasted with that of diesel. Sanjid Ahmad et al., [26] conducted an experiment on diesel engine and determined

the performance characteristics of a diesel engine using mustard oil blends. From the experimental results, 10% and 20% blends demonstrated that brake power is lesser by 7.8% while BSFC is greater by 8–13% contrasted to diesel. Ozer can [27] investigated that the characteristics of performance and exhaust emissions of a diesel engine with the utilization of waste cooking oil blends (5% and 10%) at distinct loads and observed that there is an increment in brake thermal efficiency and increment in BSFC at all loads. Fangsuwannarak et al., [28] evaluated the performance and exhaust emission of an engine utilizing palm oil with TiO_2 nano-particle mixed fuel. It is evident that exploitation of TiO_2 with diesel, engine power increases and fuel consumption is lower in contrast with diesel without additive. Hanbey hazer and Ugur ozturk [29] conducted a test on Al_2O_3–TiO_2 coated engine and the uncoated engine and assessed the performance parameters of a diesel engine utilizing corn oil methyl ester which is acquired by transesterification procedure and observed that the decrement in consumption of fuel, of all mixes utilized in coated engine contrasted with the uncoated engine.

The purpose of the present work is to change over the raw linseed oil into corresponding methyl ester with the employment of transesterification process, which utilizes methanol in the sight of a catalyst, for instance, catalyst like KOH so as to split the particle of the oil into a glycerol and ester.

The main objective of the present study is to investigate the performance characteristics of linseed oil with TiO_2 nanofluid as a coolant and methyl ester of linseed oil with TiO_2 nanofluid as a coolant at different loads. A single cylinder, diesel engine with DC generator has been chosen for the present investigation. Engine tests have been carried out to acquire the comparison of brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency and volumetric efficiency and then contrasted with diesel fuel. Experimental results showed that the methyl ester of linseed oil blends (MELSO) with TiO_2 nanofluid as a coolant gives better performance compared to linseed oil blends with TiO_2 nanofluid as a coolant.

2. METHYL ESTER OF LINSEED OIL PRODUCTION

Biodiesel production is acquired with the employment of transesterification procedure. In this procedure, the sample of linseed oil be acquired in a flask and heated to 70°C. Subsequently 250ml of methanol and 10 g of KOH catalyst is blended and stirred in a different jar. Later the mixed sample is poured in the preheated linseed oil sample and constantly mixed at 70°C. Further, this mixed sample is poured in a funnel to segregate the glycerol from methyl ester. Following 24 hours the glycerol is evacuated and isolated to acquire methyl ester. After all of this, methyl ester is to be washed and desiccated to evacuate the methanol and other contaminants. Finally, it is noticed that, for 1 litre of raw linseed oil, it delivers 850 ml Methyl ester of linseed oil (MELSO).

The following steps are required to prepare biodiesel from raw linseed oil

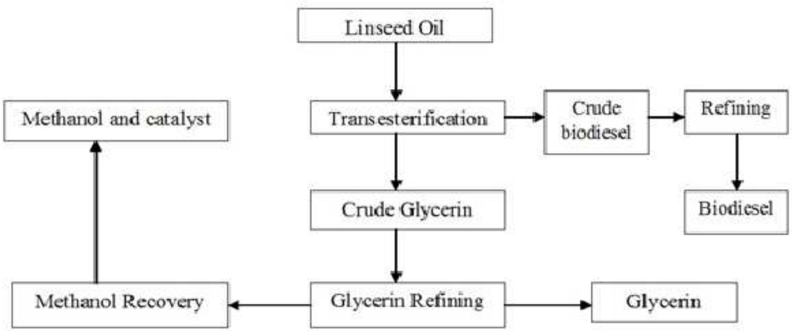

Figure 1: Flow Diagram of Production of Biodiesel from Linseed Oil.

Figure 2: Transesterification Setup.

Figure 3: Oil being Heated for Removing Fatty Acids.

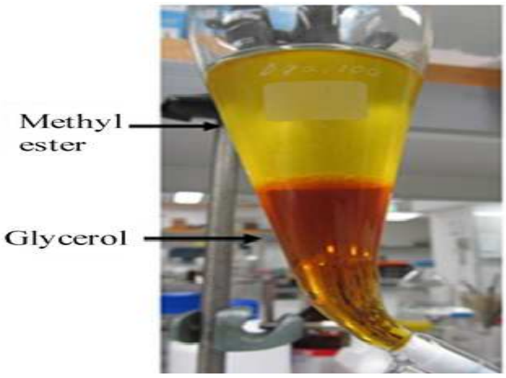

Figure 4: Separation of Product and By-Product Layers After Transesterification.

Figure 5: Methyl Ester of Linseed Oil (MELSO).

Table 1: Linseed Oil, Methyl Ester of Linseed Oil and Diesel Properties

Properties	Linseed Oil	Methyl ester of Linseed Oil	Diesel
Kinematic viscosity at 40^0C (centistokes)	26.3	4.2	2.7
Caloric value (KJ/kg)	39307	40759	45350
Flash point (^{0}C)	232	165	53
Fire point (^{0}C)	240	172	62
Density (g/cm^3)	920	865	830
Specific gravity	0.95	0.865	0.834

3. EXPERIMENTAL SET UP AND PROCEDURE

3.1. Experimental Setup

The cooling system arranged is external so that a tank limit of 50 L is filled with 45 L of water as a base liquid and with 10% concentration of nano-fluid with base liquid, i.e., 4.5 g of TiO_2 (Titanium Oxide) nano-fluid is separately mixed. With the aid of nylon rod, stirrer is coupled to the motor ensure that the stirring process is made to mix the TiO_2 nano-fluid in the base liquid. In order to prevent agglomeration of nano-fluid in the water, stirring is accomplished for 7 hours ceaselessly. Centrifugal pump is exploited to supply the water, which is mixed with TiO_2 nanofluid as a coolant to the engine. The inlet of the pump is attached to the diesel engine cooling system inlet. The cooling system outlet is set into the tank; therefore the passage of cooling fluid occurs like in a closed system.

Table 2: Diesel Engine Specifications

Make	Kirloskar Make, Compression Ignition with D. C. Generator
No. of cylinders	one
Bore	80 mm
Coefficient of discharge (C_d)	0.62
Capacity	4 KW
Diameter of Orifice (d)	20 mm
Stroke	110mm
Compression ratio	16:1
Maximum Current	13 amps
Efficiency of dynamometer	80%
Armature voltage	220V

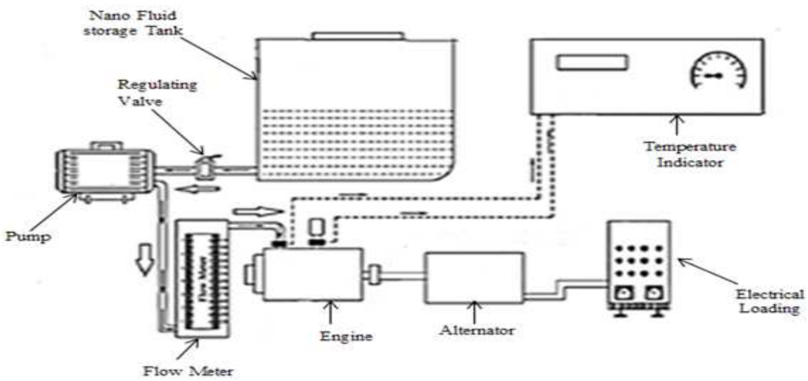

Figure 6: Layout of Experimental Setup.

Figure 7: Experimental Setup.

3.2. Experimental Procedure

A single cylinder, kirloskar compression ignition engine with DC generator has been chosen for present exploration. The layout of the experimental setup is demonstrated in figure 6. The Experimental setup is shown in figure 7.

The procedure of the experiment is discussed as below.

- Initially, the oil tank has been filled with raw linseed oil blend and then we start the engine using the valve and make sure that no-load on the engine and provide water which is mixed with TiO_2 nanofluid as a coolant to the engine.

- Allow the engine for quite a while until it achieves an enduring position at no-load condition. At no-load condition, the readings of ammeter and voltmeter, manometer readings and time taken for consumption of fuel are tabulated.
- After that, the motor is loaded with the copper plate in liquid rheostat.
- After applying the load on the engine at a stable position and note down the respective readings.
- At last, the motor is to be halted by pulling the decompression switch toward the motor cranking side.
- Different blends of linseed oil with diesel such as B10, B20, B30, B40 and B50 with TiO_2 nanofluid as a coolant and evaluated performance characteristics of a diesel engine such as brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency and volumetric efficiency.
- The same procedure is repeated for methyl ester of linseed oil (MELSO) blends with TiO_2 nanofluid as a coolant to the engine.

4. RESULTS AND DISCUSSIONS

4.1. Brake Specific Fuel Consumption

From figure 8, it is evident that BSFC of the blend B20 with TiO_2 nanofluid as a coolant is lower contrasted with diesel. Therefore, the decrement in BSFC is due to high viscosity and less amount of heat generation. The plots of brake specific fuel consumption for linseed oil blends with TiO_2 nanofluid as a coolant are demonstrated in figure 8.

From figure 9, the BSFC of the blend MELSO50 with TiO_2 nanofluid as a coolant is lesser contrasted with that of diesel. This is due to the increment in percentage of the fuel which is necessary to run the engine is lower than the increment in the percentage of brake power as comparatively a smaller amount of heat losses at higher loads. Graphs are demonstrated in the figure 9.

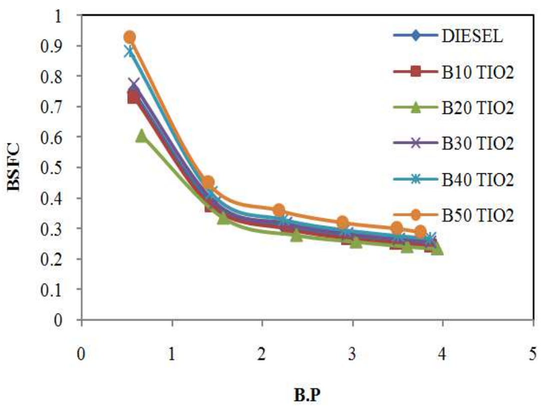

Figure 8: BSFC Vs Brake Power for Linseed Oil Blends with TiO_2 Nanofluid as a Coolant.

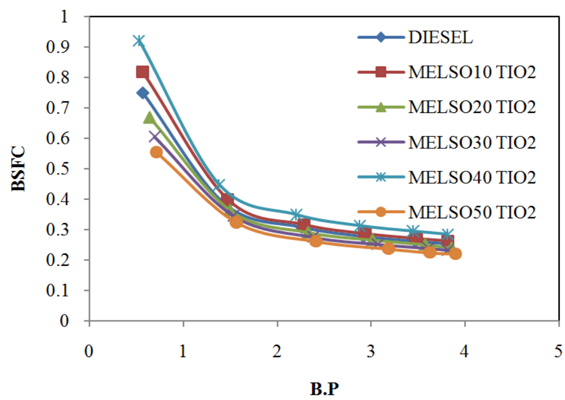

Figure 9: BSFC Vs Brake Power for Methyl Ester of Linseed oil Blends with TiO_2 Nanofluid as a Coolant.

4.2. Brake Thermal Efficiency

From figure 10, the highest brake thermal efficiency is obtained at 20% blend using TiO_2 nanofluid as a coolant (36.61%) which is greater than the diesel (31.39%). This is because of increase in load, decreases thermal dissipation and also proper consuming of fuel. The plots of brake thermal efficiency for linseed oil blends with TiO_2 nanofluid as a coolant are demonstrated in figure 10.

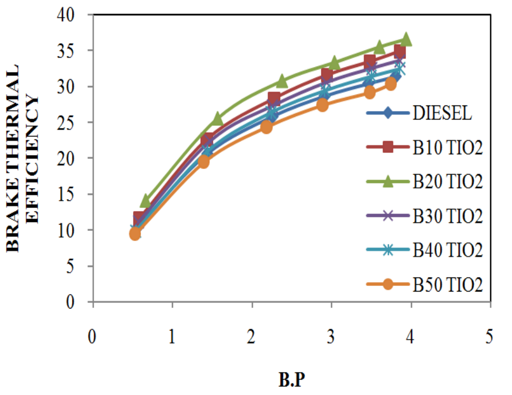

Figure 10: Brake Thermal Efficiency Vs Brake Power for Linseed Oil Blends with TiO_2 Nanofluid as a Coolant.

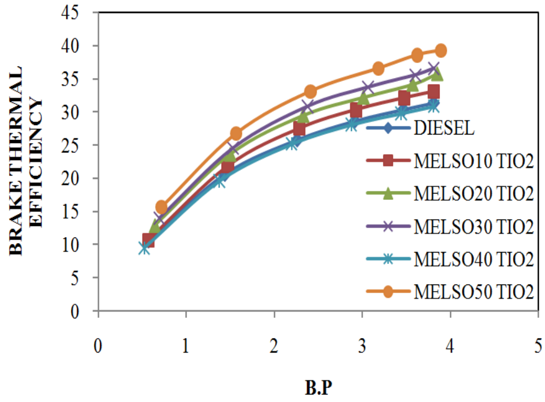

Figure 11: Brake Thermal Efficiency Vs Brake Power for Methyl Ester of Linseed Oil Blends with TiO_2 Nanofluid as a Coolant.

From figure 11, the highest brake thermal efficiency for the blend MELSO50 with TiO_2 nanofluid as a coolant (39.32%) which is greater than the diesel (31.39%) is noticed. This is because of increase in load, increases engine power. Rapid flaming is also one of the reasons for improving efficiency. Graphs are demonstrated in the figure 11.

4.3. Indicated Thermal Efficiency

From figure 12, it is noticed that the indicated thermal efficiency is greater than diesel for the blends of linseed oil. The indicated thermal efficiency in blend B20 with TiO_2 nanofluid as a coolant, increased by 4.75% in contrast with diesel at full load condition. This increment in indicated thermal efficiency was possibly a result of better ignition of fuel in contact with oxygen in the blend.

The plots of indicated thermal efficiency for methyl ester of linseed oil blends with TiO_2 nanofluid as a coolant is demonstrated in figure 13, it is observed that the blend MELSO50 with TiO_2 nanofluid as a coolant, increased by 8.35% when contrasted with diesel at full load condition. The possible reason for this might be complete combustion occurs at 50% blend.

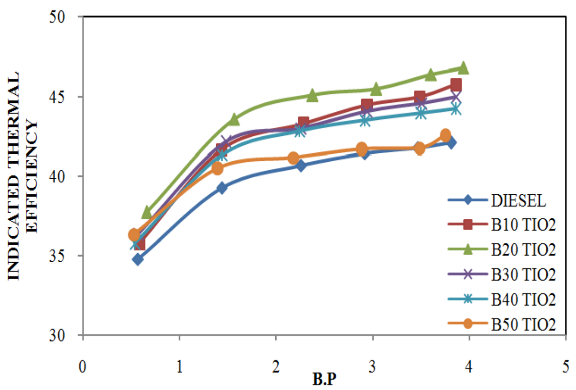

Figure 12: Indicated Thermal Efficiency Vs Brake Power for Linseed Oil Blends with TiO_2 Nanofluid as a Coolant.

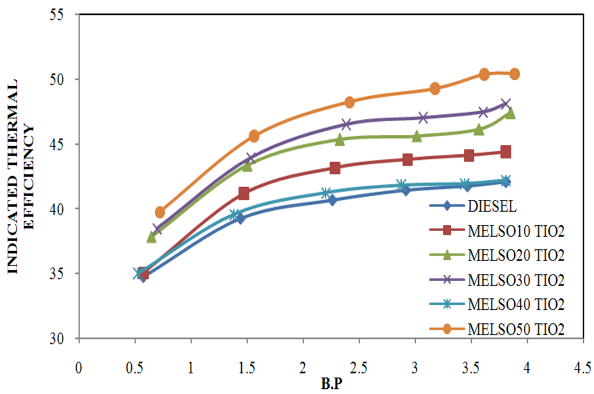

Figure 13: Indicated thermal efficiency Vs Brake Power for Methyl Ester of Linseed Oil Blends with TiO_2 Nanofluid as a Coolant.

4.4. Mechanical Efficiency

The plots of mechanical efficiency for linseed oil blends with TiO_2 nanofluid as a coolant is demonstrated in figure 14, it is found that 20% blend with TiO_2 nanofluid as a coolant is higher when compared to all other blends as a result of less friction.

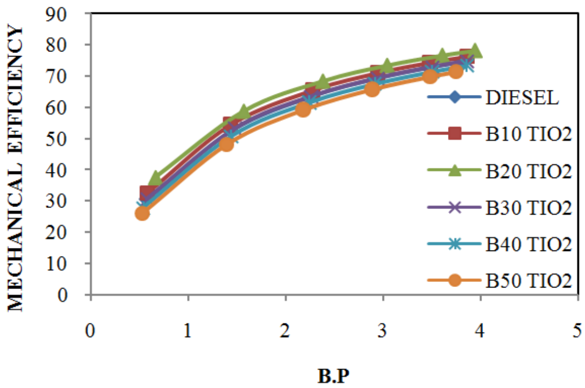

Figure 14: Mechanical efficiency Vs Brake Power for Linseed Oil Blends with TiO_2 Nanofluid as a Coolant.

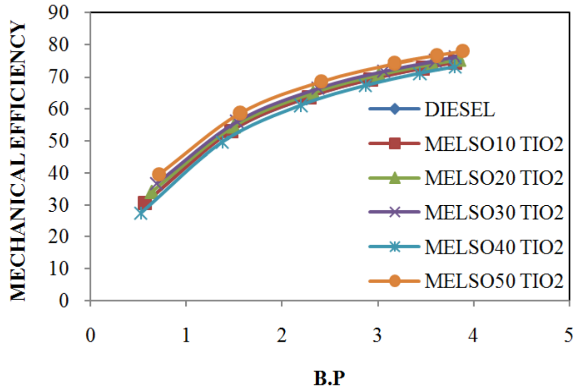

Figure 15: Mechanical efficiency Vs Brake Power for Methyl Ester of Linseed Oil Blends with TiO_2 Nanofluid as a Coolant.

From figure 15, it is clearly seen that the mechanical efficiency increases with an increase in load. It is evident that the blend MELSO50 with TiO_2 nanofluid as a coolant has higher mechanical efficiency compared to diesel. High compression ratio is also one of the reasons for increment in mechanical efficiency.

4.5. Volumetric Efficiency

From figure 16, it is noticed that the decrease in volumetric efficiency is 2.75% for all linseed oil blends with TiO_2 nanofluid as a coolant when contrasted with diesel. The decrement in volumetric efficiency is a result of reducing the proportions of admission air because of elevated temperature in the chamber.

Volumetric efficiency plots are demonstrated in figure 17, the volumetric efficiency for methyl ester of linseed oil blends with TiO_2 nanofluid as a coolant (95.22%) is greater when contrasted with diesel (91.75%). Therefore, the increment in volumetric efficiency is 3.47% for all methyl ester of linseed oil blends with TiO_2 nanofluid as a coolant at all loads.

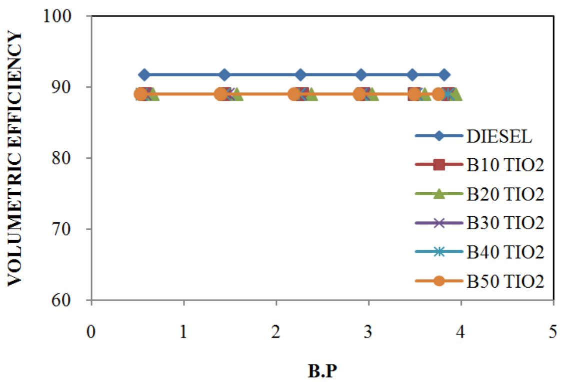

Figure 16: Volumetric Efficiency Vs Brake Power for Linseed Oil Blends with TiO_2 Nanofluid as a Coolant.

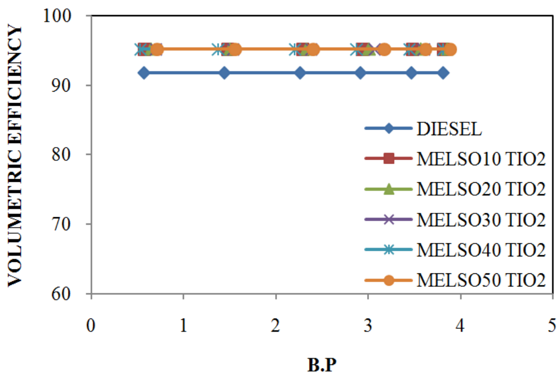

Figure 17: Volumetric Efficiency Vs Brake Power for Methyl Ester of Linseed Oil Blends with TiO_2 Nanofluid as a Coolant.

5. CONCLUSIONS

- The methyl ester of linseed oil properties is closest to the diesel by means of transesterification process.
- The BSFC for MELSO blends with TiO_2 nanofluid as a coolant is lower at all engine loads. In case of MELSO50 blend with TiO_2 nano-fluid as a coolant, the amount of reduction of BSFC is larger.
- The brake thermal efficiency at all blends for MELSO with TiO_2 nanofluid as a coolant is greater than linseed oil

blends with TiO_2 nanofluid as a coolant.

- The indicated thermal efficiency at all blends for MELSO with TiO_2 nanofluid as a coolant is greater than linseed oil blends with Ti_{O2} nanofluid as coolant.
- The mechanical efficiency for MELSO blends with Ti_{O2} nanofluid as a coolant is significantly higher than linseed oil blends with Ti_{O2} nanofluid as a coolant. This is mainly due to less friction.
- The volumetric efficiency for MELSO blends with TiO_2 nanofluid as a coolant is greater than linseed oil with TiO_2 nanofluid as a coolant, at all fuel blends. By using the MELSO blends with TiO_2 nanofluid as a coolant, the volumetric efficiency increased by 6.2% when compared with linseed oil blends with TiO_2 nanofluid as a coolant.

Finally, we concluded that the utilization of MELSO (methyl ester of linseed oil) fuelled with diesel engine with TiO_2 nano-fluid as a coolant improves engine efficiencies and decreases fuel consumption.

REFERENCES

1. *Jaswanth, A., Guru Dattatreya, G. S., & Krishnarjuna Rao N. (2019). Experimental Investigation On Linseed Oil Methyl Ester Fuelled Diesel Engine. International Journal of Mechanical and Production Engineering Research and Development (IJMPERD); ISSN (Online): 2249–8001; ISSN (Print): 2249–6890; Vol-9, Issue-3; Edition: Jun 2019.*
2. *Boipono, M., & Margret, K. "Change of Assessment Structure and Performance: The Case of PSLE Agriculture in Botswana".*
3. *Xue, J., Grift, T. E., & Hansen, A. C. (2011). Effect of biodiesel on engine performances and emissions. Renewable and Sustainable energy reviews, 15(2), 1098–1116.*
4. *Selvan, V. A. M., Anand, R. B., & Udayakumar, M. (2014). Effect of Cerium Oxide Nanoparticles and Carbon Nanotubes as fuel-borne additives in Diesterol blends on the performance, combustion and emission characteristics of a variable compression ratio engine. Fuel, 130, 160–167.*
5. *Leong, K. Y., Saidur, R., Kazi, S. N., & Mamun, A. H. (2010). Performance investigation of an automotive car radiator operated with nanofluid-based coolants (nanofluid as a coolant in a radiator). Applied Thermal Engineering, 30 (17-18), 2685–2692.*
6. *Senthilraja, S., Karthikeyan, M., & Gangadevi, R. (2010). Nanofluid applications in future automobiles: comprehensive review of existing data. Nano-Micro Letters, 2(4), 306–310.*
7. *Sidik, N. A. C., Yazid, M. N. A. W. M., & Mamat, R. (2015). A review on the application of nanofluids in vehicle engine cooling system. International Communications in Heat and Mass Transfer, 68, 85–90.*
8. *McCarthy, P., Rasul, M. G., & Moazzem, S. (2011). Analysis and comparison of performance and emissions of an internal combustion engine fuelled with petroleum diesel and different bio-diesels. Fuel, 90 (6), 2147–2157.*
9. *Chauhan, B. S., Kumar, N., & Cho, H. M. (2010). Performance and emission studies on an agriculture engine on neat Jatropha oil. Journal of Mechanical Science and Technology, 24(2), 529–535.*
10. *Chen, J., & Jia, J. (2017). Experimental study of TiO2 nanofluid coolant for automobile cooling applications. Materials Research Innovations, 21 (3), 177–181.*
11. *Balamurugan, T., Arun, A., & Sathishkumar, G. B. (2018). Biodiesel derived from corn oil–A fuel substitute for diesel. Renewable and Sustainable Energy Reviews, 94, 772–778.*
12. *Dixit, S., & Rehman, A. (2012). Linseed oil as a potential resource for bio-diesel: a review. Renewable and Sustainable*

Energy Reviews, 16(7), 4415–4421.

13. *Raju, V. D., & Kumar, P. R. (2012). Experimental investigation of linseed and neem methyl esters as biodiesel on CI engine. International Journal of Engineering Science and Technology (IJEST), 4(06).*
14. *Hemanandh, J., & Narayanan, K. V. (2015). Emission and performance analysis of hydro treated refined sunflower oil as alternate fuel. Alexandria Engineering Journal, 54(3), 389–393.*
15. *Vaghri, S., & Mohan, K. G. (2014). "An Optimal Data Placement Framework to Increase Performance BOF Map-Reduce for Data-Intensive Applications with Interest Locality".*
16. *Puhan, S., Jegan, R., Balasubbramanian, K., & Nagarajan, G. (2009). Effect of injection pressure on performance, emission and combustion characteristics of high linolenic linseed oil methyl ester in a DI diesel engine. Renewable energy, 34(5), 1227–1233.*
17. *Teja, S. B. (2018). Experimental Investigation on the Performance, Emission and Combustion Characteristics of DI Diesel Engine with Linseed Methyl Ester along with Methanol Carburization. Materials Today: Proceedings, 5(2), 6470–6480.*
18. *Rao, P. S., Rao, K. S., & Rao, G. V. (2013). Performance and Emission Characteristics of Diesel Engine Fuelled by Biodiesel Derived from Linseed Oil. International Journal of Engineering Research & Technology (IJERT) Vol, 2, 2278–0181.*
19. *Javed, S., Shariff, A. R. B. M., & Nathan, S. "Influences of Hockey Coaches, Team Cohesion and Motivational Intensity on The Performance of Pakistani Field Hockey Players".*
20. *Kumar, R., Tiwari, P., & Garg, S. (2013). Alkali transesterification of linseed oil for biodiesel production. Fuel, 104, 553–560.*
21. *Chauhan, B. S., Kumar, N., & Cho, H. M. (2012). A study on the performance and emission of a diesel engine fueled with Jatropha biodiesel oil and its blends. Energy, 37 (1), 616–622.*
22. *Vijayaraj, K., & Sathiyagnanam, A. P. (2016). Experimental investigation of a diesel engine with methyl ester of mango seed oil and diesel blends. Alexandria engineering journal, 55 (1), 215–221.*
23. *Uyumaz, A. (2018). Combustion, performance and emission characteristics of a DI diesel engine fueled with mustard oil biodiesel fuel blends at different engine loads. Fuel, 212, 256–267.*
24. *Gopal, K. N., & Raj, R. T. K. (2016). Effect of pongamia oil methyl ester–diesel blend on lubricating oil degradation of di compression ignition engine. Fuel, 165, 105–114.*
25. *Yilmaz, N. (2012). Performance and emission characteristics of a diesel engine fuelled with biodiesel-ethanol and biodiesel-methanol blends at elevated air temperatures. Fuel, 94, 440–443.*
26. *Nalgundwar, A., Paul, B., & Sharma, S. K. (2016). Comparison of performance and emissions characteristics of DI CI engine fueled with dual biodiesel blends of palm and jatropha. Fuel, 173, 172–179.*
27. *Ravikumar, C. S., & Thandavamoorthy, T. S. (2014). "Application of FRP for strenghtening and retrofitting of civil engineering structures". Int. J. Civ. Struct. Env. Infrastr. Eng. Res. Dev, 4, 49–60.*
28. *Basha, J. S., & Anand, R. B. (2014). Performance, emission and combustion characteristics of a diesel engine using Carbon Nanotubes blended Jatropha Methyl Ester Emulsions. Alexandria Engineering Journal, 53(2), 259–273.*
29. *Sanjid, A., Masjuki, H. H., Kalam, M. A., Rahman, S. A., Abedin, M. J., & Palash, S. M. (2014). Production of palm and jatropha based biodiesel and investigation of palm-jatropha combined blend properties, performance, exhaust emission and noise in an unmodified diesel engine. Journal of Cleaner Production, 65, 295–303.*
30. *Ahmed, S., Hassan, M. H., Kalam, M. A., Rahman, S. A., Abedin, M. J., & Shahir, A. (2014). An experimental investigation of*

biodiesel production, characterization, engine performance, emission and noise of Brassica juncea methyl ester and its blends. Journal of cleaner production, 79, 74–81.

31. *Can, Ö. (2014). "Combustion characteristics, performance and exhaust emissions of a diesel engine fueled with a waste cooking oil biodiesel mixture". Energy Conversion and Management, 87, 676–686.*
32. *Fangsuwannarak, K., & Triratanasirichai, K. (2013). "Effect of metalloid compound and bio-solution additives on biodiesel engine performance and exhaust emissions". American journal of applied sciences, 10 (10), 1201.*
33. *Hazar, H., & Ozturk, U. (2010). "The effects of Al2O3–TiO2 coating in a diesel engine on performance and emission of corn oil methyl ester". Renewable Energy, 35(10), 2211–2216.*

AUTHOR'S PROFILE

A.JASWANTH received the B.Tech degree in Mechanical Engineering from the SIDDHARTH INSTITUTE OF ENGINEERING AND TECHNOLOGY (SIETK), Puttur, affiliated to Jawaharlal Nehru Technological University Anantapur (JNTUA), Andhra Pradesh, India.

Currently Pursuing M.Tech in Thermal Science and Energy Systems (TSES) from G. PULLA REDDY ENGINEERING COLLEGE (GPREC), (Autonomous), Kurnool, affiliated to Jawaharlal Nehru Technological University Anantapur (JNTUA), Andhra Pradesh, India.

G. S. GURU DATTATREYA, Assistant Professor, Department of Mechanical Engineering, G. Pulla Reddy Engineering college (Autonomous), Kurnool, Andhra Pradesh, India. Pursued B.Tech in Mechanical Engineering from G. Pulla Reddy Engineering college (Autonomous), Kurnool. Pursued Post Graduation in Advanced IC engines from JNTUA, Ananthapur. He published 8 international Journals. 3 Papers were presented in the conference at national level. His research interest includes Thermal/IC engines.

B. VEERABHADRA REDDY, Professor, Department of Mechanical Engineering, G. Pulla Reddy Engineering College (Autonomous), Kurnool, Andhra Pradesh, India. Pursued B.Tech in Mechanical Engineering from Nagarjuna University. Pursued Post Graduation in Heat Power from JNTU, Hyderabad. Pursued Ph.D in IC Engines from JNTU, Hyderabad. He Published 9 international journals and 2 national journals. 4 papers were presented in the conference at international level and 3 papers at national level. He has a total Teaching Experience of 18 years. He Guided 9 Projects at Master Level and Ph.Ds 2 (Guiding). His professional Memberships in MISTE, MCI(I), FSSc. His research interest includes IC Engines.